Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

Predicting post-electrical injury autonomic dysfunction symptom occurrence by a simple test

Sharareh Roshanzamir [a], Alireza Dabbaghmanesh [b,*], Alireza Ashraf [c]

[a] Department of Physical Medicine and Rehabilitation, International Branch, Shiraz University of Medical Sciences, Shiraz, Iran

[b] Shahrekord University of Medical Sciences, Shahrekord, Iran

[c] Burn Research Center, Shiraz University of Medical Sciences, Shiraz, Iran

ARTICLE INFO

Article history:
Accepted 21 August 2013

Keywords:
Autonomic derangement symptoms
Electrical burn injury
Sympathetic skin response

ABSTRACT

Background: Sensory, motor, and autonomic neuropathy has been reported after electrical injury. Besides subclinical involvement of the sympathetic nervous system during the 1st year post injury, late clinical manifestations of this involvement have been reported sporadically. This study was designed to investigate how the clinical and electrodiagnostic manifestations of sympathetic involvement would change with time in electricity victims.

Methods and materials: Sixty electrically burnt patients were followed for 22 months with sympathetic skin response (SSR) and autonomic system derangement symptom surveillance.

Results: Thirty-one patients reported autonomic derangement symptoms during the 2nd year post injury. SSR latency prolongation showed direct negative correlation with time; but SSR amplitude was decreased in all cases irrespective of the time laps. Symptomatic patients showed significantly lower SSR amplitudes compared to asymptomatic ones. This was true for the pre-symptom SSR test results too.

Conclusion: SSR amplitude can be used as a predictive test for the symptoms of autonomic derangement to occur post electrical injury.

© 2013 Published by Elsevier Ltd and ISBI.

1. Introduction

In Shiraz burn hospital, south of Iran, electrical injury is responsible for 4.73% of referrals [1]. Neurological (81.6%) and psychological (71%) symptoms have been mentioned as the most common sequel of electrical burn injury. In one study the neurological symptoms occurred at 5.3 months post-burn [2]. Compressive peripheral neuropathy is one of the systemic effects of low voltage electrical burn [3]. Electrophysiologic studies have detected peripheral polyneuropathy as early as 1 weak post burn. Some scientists believe that this is due to acute phase reactants released in response to burn, since it subsides with time [4]. But long-term involvement of the motor nervous system has been shown in another study [5].

Following a case report indicating sympathetic nervous system involvement in electrical burn [6], Ashraf et al. showed subclinical involvement of the sympathetic nervous system up to 1-year post electrical injury [7]. We wondered how the electrodiagnostic features of autonomic derangement would change with time and how it might be related to clinical manifestations of this derangement. The present study was designed in response to such concerns.

* *Corresponding author.*
E-mail address: dabbaghmanesh.alireza@yahoo.com (A. Dabbaghmanesh).
0305-4179/$36.00 © 2013 Published by Elsevier Ltd and ISBI.
http://dx.doi.org/10.1016/j.burns.2013.08.033

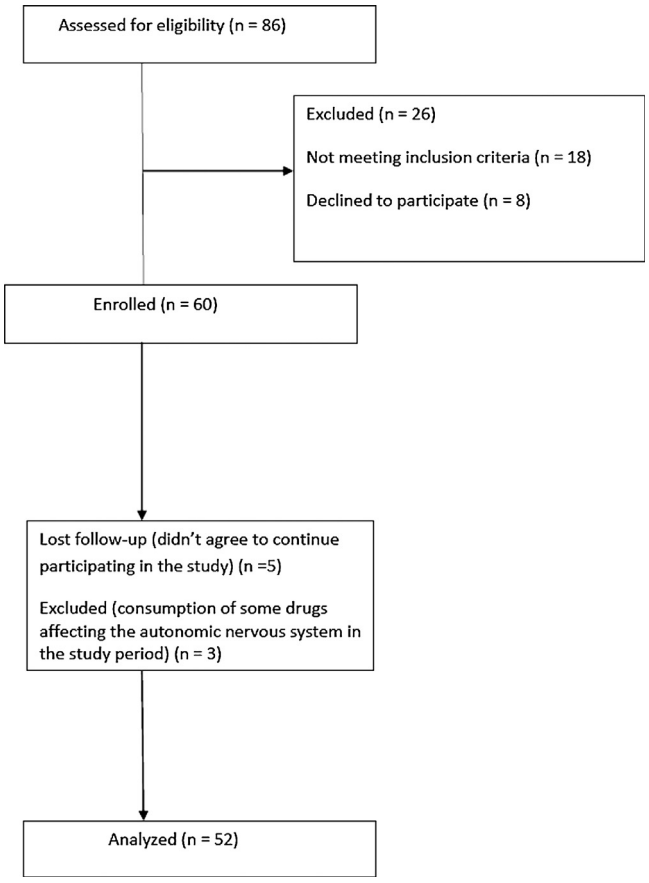

Fig. 1 – CONSORT diagram of the study flow.

2. Methods and materials

Among the 86 registered electrical burn patients in Shiraz burn center (Ghotbedin Hospital), 60 that agreed to participate in the study and had none of the exclusion criteria (known peripheral neuropathic disease, Diabetes mellitus, or consumption of any drug affecting autonomic nervous system) were followed for 22 months. The CONSORT diagram for the patient flow through the study is displayed in Fig. 1. We got the approval of Shiraz University of medical sciences (International branch). After filling in the informed consent, subjects went under

2.1. SSR test

This test was taken by a Synergy multilinker EMG machine in a quiet room, having the patient in the supine position. The patients were invited to keep the eyes open, so that the quiescence of the environment would not make them asleep, and avoid laughing, sighing, coughing, or breathing deeply. By these measures we tried to prohibit any confounding factor from affecting SSR parameters. The room and skin temperatures were kept at 24 °C and 32 °C respectively. For the upper extremities we put the active electrode on the palm and the reference one on the dorsum of each hand to record the SSR to the median nerve stimulation at the wrist. And for lower extremities, we put the active and reference electrodes on the sole and dorsum of each foot respectively to record the response to tibial nerve stimulation at the ankle. We used a band pass of 0.5–2 KHz, amplification of 100–200 mV/div and a base time of 500 ms/div. Thirteen stimuli of 20–45 mA and 0.3 ms duration were administered at random intervals of more than 30 s [7–10].

Peak to peak amplitude and onset latency of the SSR were the measured parameters. Since we had already established the normal values of SSR latency and amplitude of our lab, we used these norms, (Tables 1 and 2) instead of taking a control group.

A questionnaire to detect any symptom of autonomic derangement was also filled for each patient. In this questionnaire 'normal' (no symptom) was indicative of never or almost never experiencing the symptom, 'mild' was indicative of experiencing the symptom several times a month, 'moderate' was indicative of experiencing the symptom several times a week, and 'severe' was representative of experiencing the symptom daily. SSR test and filling in the same questionnaire were repeated at 5, 10, 15 and 22 months after electrical exposure. In statistical analysis of the data, the repeated measure test was used to analyze the changes of amplitude and latency of the SSR with time, and *t*-test was used for comparison of these tow parameters between the symptomatic and asymptomatic groups, and between the electrical burn patients and normal values.

3. Results

At the beginning of the study the time laps between the electrical exposure of the subjects and the study was 2–5 months. We lost the follow up of 5 patients. And 3 patients were excluded due to consumption of some drugs affecting the autonomic nervous system in the study period. One of these received Pregabalin and Neurotriptiline for the management of severe aching pain in the right hand (which was also the entry site of electricity). The pain began 14 months post injury and lasted for 2 months. The 2 SSRs taken from this patient showed very low amplitude responses recorded from right hand (40% of the left hand response amplitude and 30% and 36% of the mean amplitude taken from the other patients' right hands in the first and 2nd SSR tests respectively).

Table 1 – Reference values of the sympathetic skin response amplitude.

	RP amp	LP amp	RS amp	LS amp
Mean	527	518	515	514
Std. deviation	92	78	92	90
Minimum	280	305	280	54
Maximum	785	745	760	765
Percentiles				
25	475	475	460	460
50	530	520	517	515
75	580	565	570	565

RP: right palm; amp: amplitude; LP: left palm; RS: right sole; LS: left sole

Table 2 – Reference values of the sympathetic skin response latencies.

	RP amp	LP amp	RS amp	LS amp
Mean	1.3	1.3	1.7	1.7
Std. deviation	0.2	0.2	0.2	0.2
Minimum	0.9	0.9	1.0	1.0
Maximum	1.9	1.9	2.2	2.2
Percentile				
25	1.2	1.2	1.6	1.6
50	1.3	1.3	1.8	1.8
75	1.5	1.5	1.9	1.9

RP: right palm; lat: latency; LP: left palm; RS: right sole; LS: left sole.

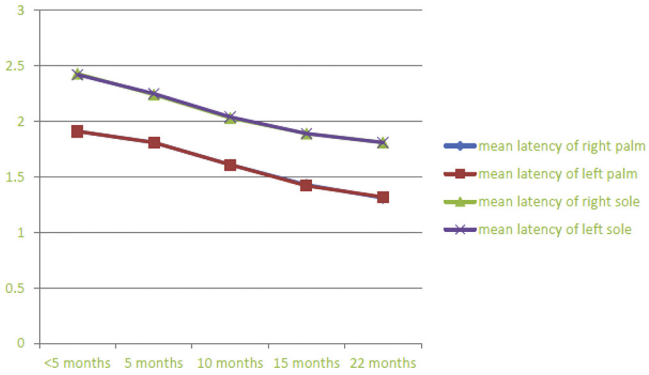

Plate 1 – Changes of sympathetic skin response latency with time in electrical burn patient.

The remaining 52 patients were of mean age of 34.33 years. They were all male. Thirty-one patients reported some autonomic derangement symptoms between 14 and 23 months post injury (Table 3). The symptomatic and asymptomatic patients were not significantly different regarding age. There was also no significant difference between high and low voltage electricity in causing the symptoms.

The SSR latency prolongation showed direct negative correlation with time; so as this prolongation gradually approached the normal values by 2 years post injury (graph 1). The SSR amplitude however was significantly below normal values irrespective of time pass ($P < 0.05$) (Table 4). This reduction was more prominent in all 5 SSR tests in the symptomatic compared to asymptomatic patients ($P < 0.05$) (Tables 5–8). No significant SSR difference was detected between the 2 sides of the body in any of the tests except for lower amplitude in the right hand compared to the left one wherever it was the entry site of electricity.

4. Discussion

Several studies have been conducted to date, investigating the short or long-term sequel of electrical burn [3,11–13]. According to the results 59.6% of the electrical burn patients developed symptoms of sympathetic system derangement 14 to 23 months post injury. This is much later than 5.3 months reported for the neurologic symptoms in these patients previously [2]. Although all the patients reported their symptoms as mild to moderate and none of them sake medical help for symptom management, these symptoms may affect the quality of life and psychosocial health of these patients negatively. One of the major shortcomings of this study is that we didn't consider these two important aspects.

Regarding the fact that most of the electrical burn patients are in their productive years of life, in time detection and control of sympathetic derangement can prevent many psychological, social, and financial complications.

Many diagnostic tests have been used to detect abnormalities and predict long-term sequel in electrical burn. X-ray, CT scan, MRI, and bone scan have all failed to correlate with the long-term symptoms of electrical injury [14]. Nuclear imaging of the brain has been mentioned as a means of predicting the neurologic sequelae of the electrical burn [15]. But this is an expensive, hardly available test.

Since the SSR amplitude of the symptomatic patients is significantly lower than asymptomatic ones even in the silent period, this factor may be a good candidate for predicting clinically evident derangement, giving us the chance to be ahead of the symptoms.

One of the patients failed to complete the study since he developed an exclusion criterion (consumption of drugs affecting autonomic nervous system) in the study period. These drugs were prescribed for him to manage a severe aching pain in the right hand. The point of interest in this patient is that the right hand was the entry site of electricity. The possibility of delayed sympathetically maintained pain in the entry and exit sites of electricity has been reported previously [16]. Whether sympathetic derangement played any role in the painful attack is a mystery that needs more studies to be clarified.

Another interesting point in this patient is that SSR amplitude of the right hand was just 40% of the left one and 30% and 36% of the mean amplitude taken from the other

Table 3 – symptoms reported by the patients during the study period.

Symptom	N	Beginning/M (m)	Duration/M (m)	Subjective severity
Orthostatic lightheadedness	8	16	4	12 mild 6 moderate
Erectile dysfunction	16	18	8	Mild
Cold/warmth intolerance	5	15	6	Moderate
Tachycardia at rest	4	19.6	3	Moderate

N: number of the patients reporting the symptom; M: month; m: mean.

Table 4 – Comparing the sympathetic skin response amplitude of the electrical burn patient normal values.

		Mean	Std. deviation	Sig
Right palm	Normal value	527	92	
	<5 months post electrical bum	320	37	.000
	5 months post electrical bum	320	36	.000
	10 months post electrical burn 15	321	36	.000
	months post electrical burn 22	317	31	.000
	22 months post electrical burn	319	38	.000
Left palm	Normal value	518	78	
	<5 months post electrical bum	321	34	.000
	5 months post electrical bum	319	34	.000
	10 months post electrical bum	322	36	.000
	15 months post electrical burn	321	30	.000
	22 months post electrical burn	324	34	.000
Right sole	Normal value	515	92	
	<5 months post electrical bum	228	27	.000
	5 months post electrical bum	231	33	.000
	10 months post electrical bum	224	25	.000
	15 months post electrical burn	230	29	.000
	22 months post electrical burn	227	29	.000
Left sole	Normal value	514	90	
	<5 months post electrical bum	228	29	.000
	5 months post electrical bum	227	27	.000
	10 months post electrical bum	229	30	.000
	15 months post electrical burn	228	26	.000
	22 months post electrical burn	231	31	.000

Table 5 – comparing the right palm sympathetic skin response amplitude between symptomatic and asymptomatic patients.

		Mean	Std. deviation	Sig
<5 months post-burn	Symptomatic	292	13	.000
	Asymptomatic	362	14	
5 months post-bum	Symptomatic	292	12	.000
	Asymptomatic	360	14	
10 months post-burn	Symptomatic	293	15	.000
	Asymptomatic	362	7	
15 months post-burn	Symptomatic	293	12	.000
	Asymptomatic	354	9	
22 months post-burn	Symptomatic	291	19	.000
	Asymptomatic	361	9	

Table 6 – comparing the left palm sympathetic skin response amplitude between symptomatic and asymptomatic patients.

		Mean	Std. deviation	Sig
<5 months post-burn	Symptomatic	294	11	.000
	Asymptomatic	360	11	
5 months post-bum	Symptomatic	294	16	.000
	Asymptomatic	357	11	
10 months post-bum	Symptomatic	294	15	.000
	Asymptomatic	364	7	
15 months post-bum	Symptomatic	298	11	.000
	Asymptomatic	356	9	
22 months post-bum	Symptomatic	299	18	.000
	Asymptomatic	361	8	

patients' right hands in the same time SSR tests respectively. These tests were taken before the appearance of the pain. This also approves that SSR amplitude can be used as a predictive factor in this regard. Right hand has been mentioned to be more sensitive to SSR changes than the left one in some other studies [7,17].

The reduction in amplitude of SSR in the electrical burn patients that does not correct with time (at least for 2 years)

Table 7 – comparing the right sole sympathetic skin response amplitude between symptomatic and asymptomatic patients.

		Mean	Std. deviation	Sig
<5 months post-burn	Symptomatic	207	6	.000
	Asymptomatic	259	14	
5 months post-bum	Symptomatic	205	10	.000
	Asymptomatic	269	14	
10 months post-burn	Symptomatic	204	6	.000
	Asymptomatic	253	12	
15 months post-bum	Symptomatic	208	12	.000
	Asymptomatic	264	9	
22 months post-burn	Symptomatic	204	9	.000
	Asymptomatic	260	12	

Table 8 – comparing the left sole sympathetic skin response amplitude between symptomatic and asymptomatic patients.

		Mean	Std. deviation	Sig
<5 months post-burn	Symptomatic	206	8	.000
	Asymptomatic	261	15	
5 months post-bum	Symptomatic	207	8	.000
	Asymptomatic	258	14	
10 months post-bum	Symptomatic	206	9	.000
	Asymptomatic	263	12	
15 months post-bum	symptomatic	208	9	.000
	Asymptomatic	257	13	
22 months post-bum	Symptomatic	206	10	.000
	Asymptomatic	267		

may be due to the axonal injury of the sympathetic nervous system at the time of electrical burn. But since SSR is dependent on the function of the sweat glands too, the reduction in amplitude may be due to the reduction or malfunction of the sweat glands, rather than axonal injury. So further studies, both functional and histological is needed to clarify the exact cause of this reduction.

5. Conclusion

SSR may be a good candidate as an available, comfortable, and easily taken test to predict the long-term sympathetically induced sequel of electrical burn injury.

Conflicts of interest statement

There are no conflicts of interest to declare.

Acknowledgment

This paper has been driven out of the theses of Farnoosh Mohebzadeh, Ashkan Shafiei, and Alireza Shaghaghian, medical students of international branch, Shiraz University of medical sciences, Shiraz, Iran, with respective numbers of 85/1020, 86/1000, and 1000.

REFERENCES

[1] Mohammadi AA, Amini M, Mehrabani D, Kiani Z, Seddigh A. A survey on 30 months electrical burns in Shiraz University of Medical Sciences Burn Hospital. Burns 2008;34:111–3.
[2] Singerman J, Gomez M, Fish JS. Long-term sequelae of low-voltage electrical injury. J Burn Care Res 2008;29:773–7.
[3] Smith MA, Muehlberger T, Dellon AL. Peripheral nerve compression associated with low-voltage electrical injury without associated significant cutaneous burn. Plast Reconstr Surg 2002;109:137–44.
[4] Margherita AJ, Robinson LR, Heimbach DM, Fishfader VL, Schneider VA, Jones D. Burn-associated peripheral polyneuropathy A search for causative factor. Am J Phys Med Rehabil 1995;74:28–32.
[5] Haberal MA, Gurer S, Akman N, Basgoze O. Persistent peripheral nerve pathologies in patients with electric burns. J Burn Care Rehabil 1996;17:147–9.
[6] Lim EH, Sood MK, Dziewulski P. Unilateral palmar and axillary hyperhidrosis post electrical flash burn. Burns 2006;32:389–90.
[7] Ashraf A, Mohammadi A, Roshanzamir S, Ayaz M, Tolide-ie H, Ghasempoor MZ. Sympathetic skin response in electrical burn injury. Burns 2012;38:232–5.
[8] Mondelli M, et al. Sympathetic skin response in primary Raynaud's phenomenon. Clin Auton Res 2009;19(6):355–62.
[9] Kucera P, Goldenberg Z, Kurca E. Sympathetic skin response: review of the method and its clinical use. Bratisl Lek Listy 2004;105(3):108–16.

[10] Mondelli M, et al. Sympathetic skin response before and after surgical release of carpal tunnel syndrome. Muscle Nerve 2001;24(1):130–3.
[11] Scholz T, Rippmann V, Wojtecki L, Perbix W, Rothschild MA, Spilker G. Severe brain damage by current flow after electrical burn injury. J Burn Care Res 2006;27:917–22.
[12] Deveci M, Bozkurt M, Sengezer M. Clonus: an unusual delayed neurological complication in electrical burn injury. Burns 2001;27:647–51.
[13] Mazzetto-Betti KC, Amancio AC, Farina Jr JA, Barros ME, Fonseca MC. High-voltage electrical burn injuries: functional upper extremity assessment. Burns 2009;35:707–13.
[14] Fish JS, Theman K, Gomez M. Diagnosis of long-term sequelae after low-voltage electrical injury. J Burn Care Res 2012;33:199–205.
[15] Deveci M, Bozkurt M, Arslan N, Sengezer M. Nuclear imaging of the brain in electrical burn patients. Burns 2002;28:591–4.
[16] Aldrete JA, Ghaly R. Delayed sympathetically maintained pain caused by electrical burn at the current's entry and exit sites. J Pain Symptom Manage 1994;9:541–3.
[17] Ashraf AR, Taghavi AR, Moghtaderi AR, Sedaghat P. Sympathetic skin response (SSR) in Crohn disease: a pilot study. Electromyogr Clin Neurophysiol 2010;50:29–31.